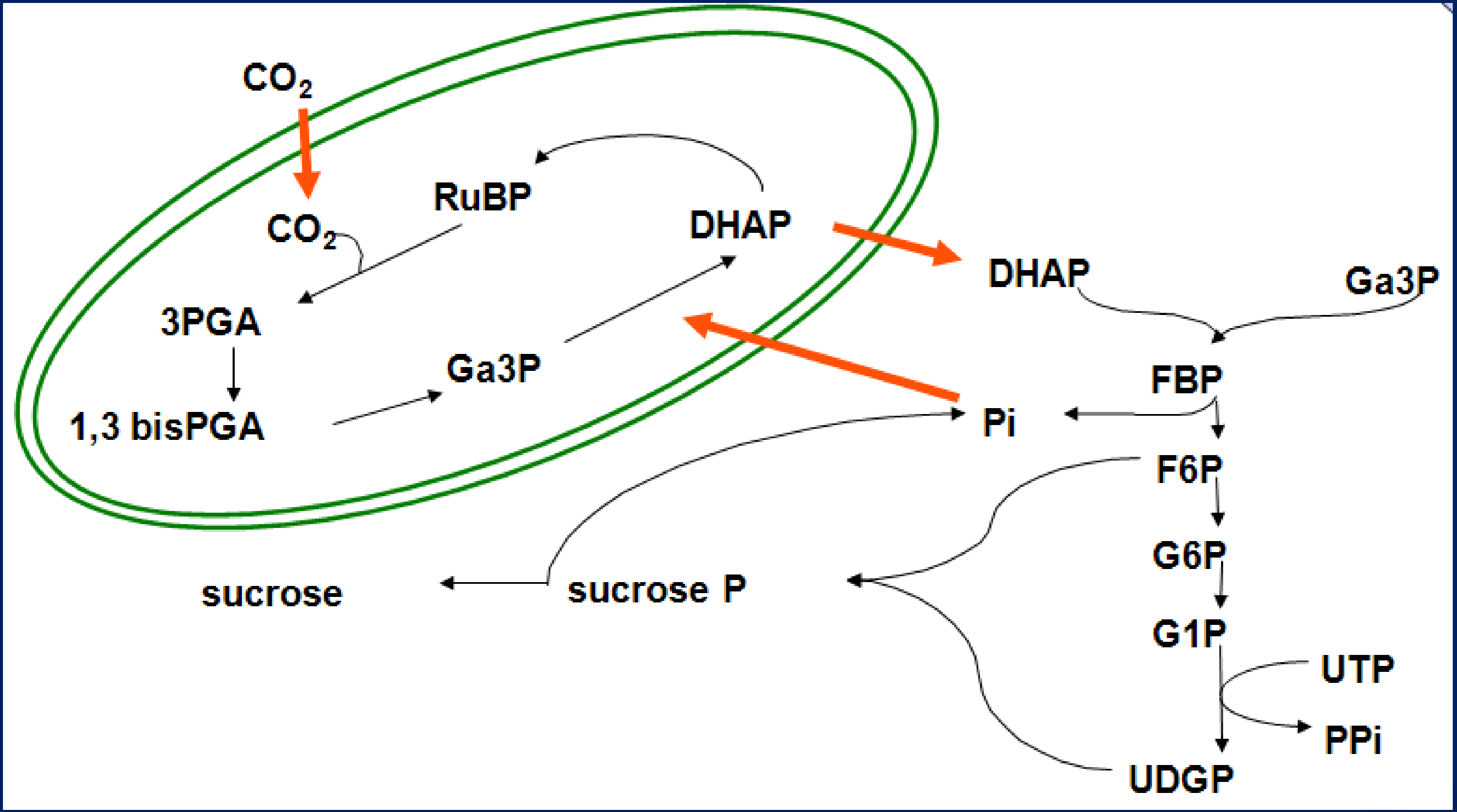
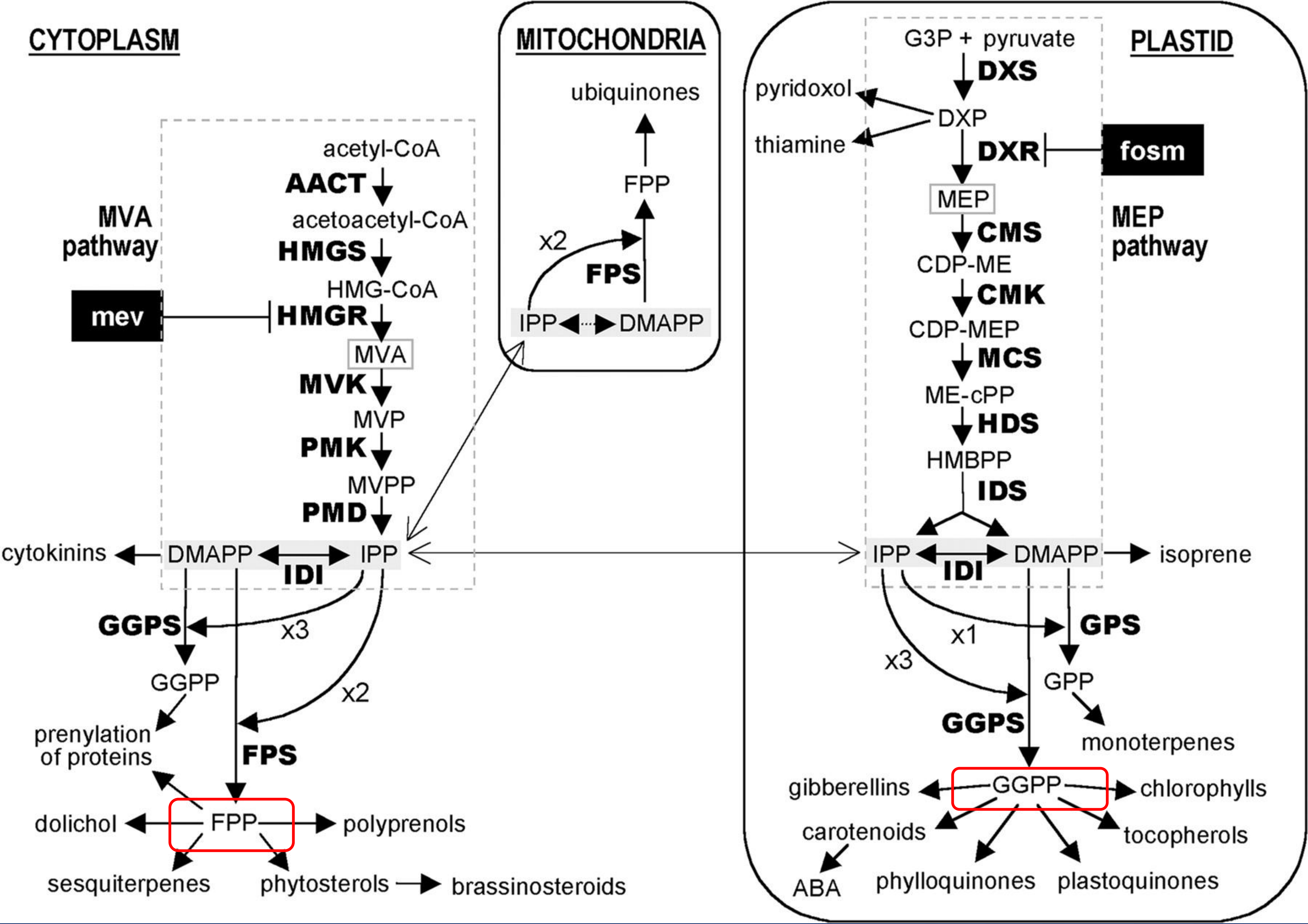
Plant-specific biosynthesis

- Sugars
- Plastide-specific synthesis (AA, FA, antibiotics, carotenoids, vitamins, quinones)
- Cell wall synthesis

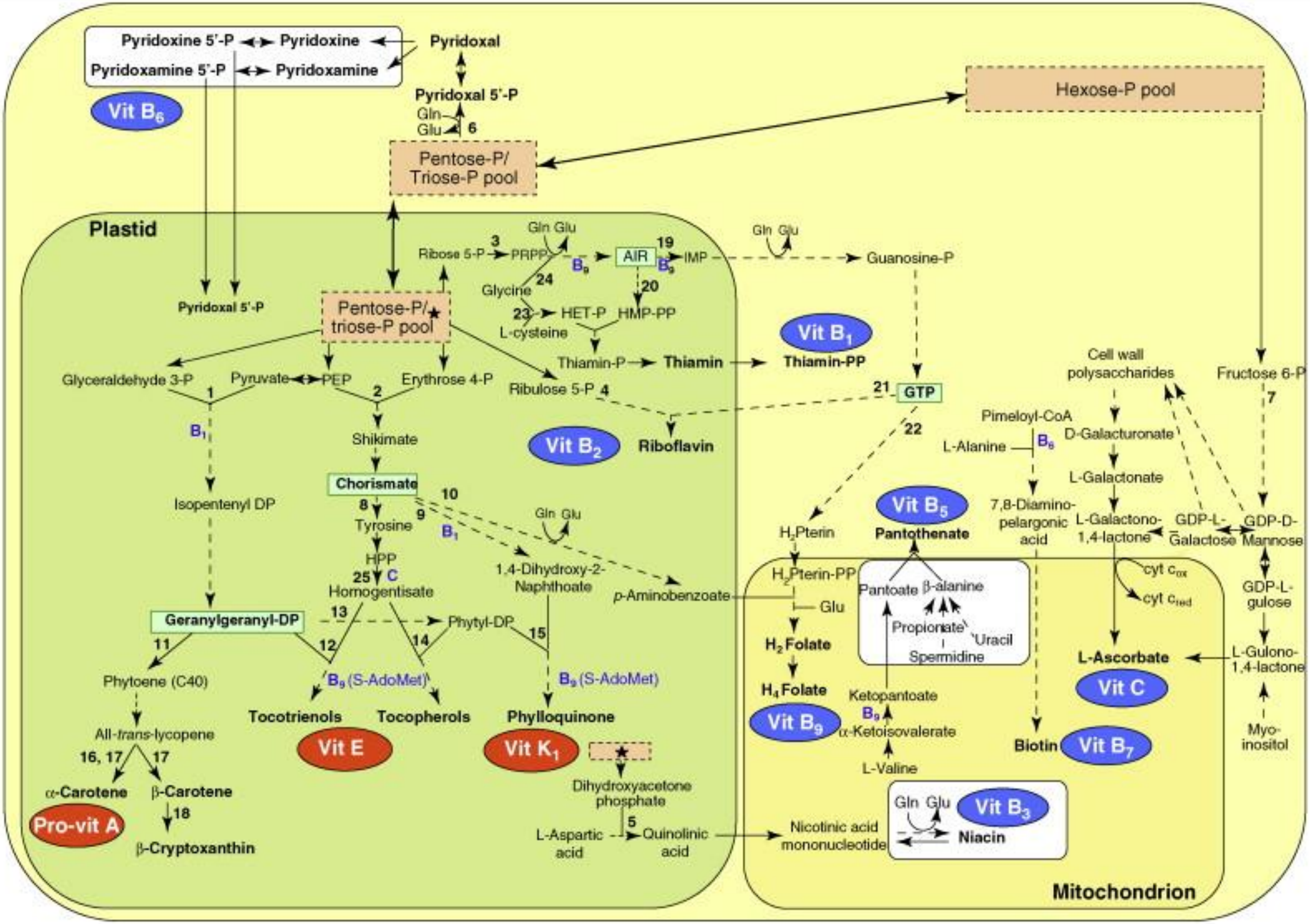
Pathway of sucrose synthesis from CO_2



DHAP=dihydroxyacetonephosphate
RuBP= ribulose-biphosphate



FPP = farnesylpyrophosphate; GGPP = geranylgeranylpyrophosphate



TRENDS in Plant Science

Biochemistry inside plastids

- Photosynthesis – reduction of C, N, and S
- Amino acids, essential amino acid synthesis restricted to plastids
  - Phenylpropanoid amino acids and secondary compounds start in the plastids (shikimic acid pathway)
  - Site of action of several herbicides, including glyphosate
  - Branched-chain amino acids
  - Sulfur amino acids
- Fatty acids – all fatty acids in plants made in plastids
- Carotenoids – source of vitamin A
- Thiamin and pyridoxal, B vitamins
- Ascorbic acid – vitamin C
- Tocopherol – vitamin E
- Phylloquinone (an electron acceptor in PS I – vitamin K)

The Cell wall is made of two or three structurally independent networks

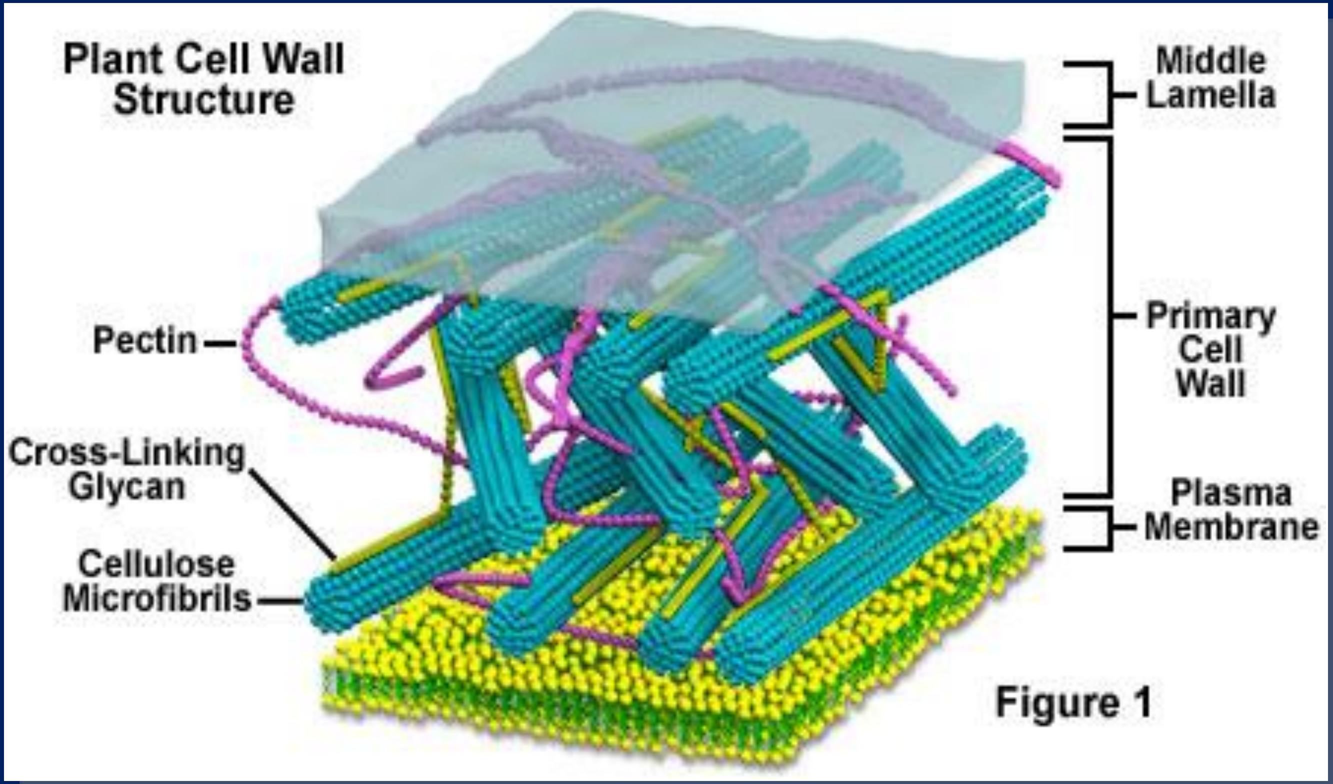
These networks interlace.

1)Cellulose and cross-linking glycans

2)Pectic polysaccarides

3)Structural proteins and/or phenylpropanoid network

Synthesis of plant Cell Wall

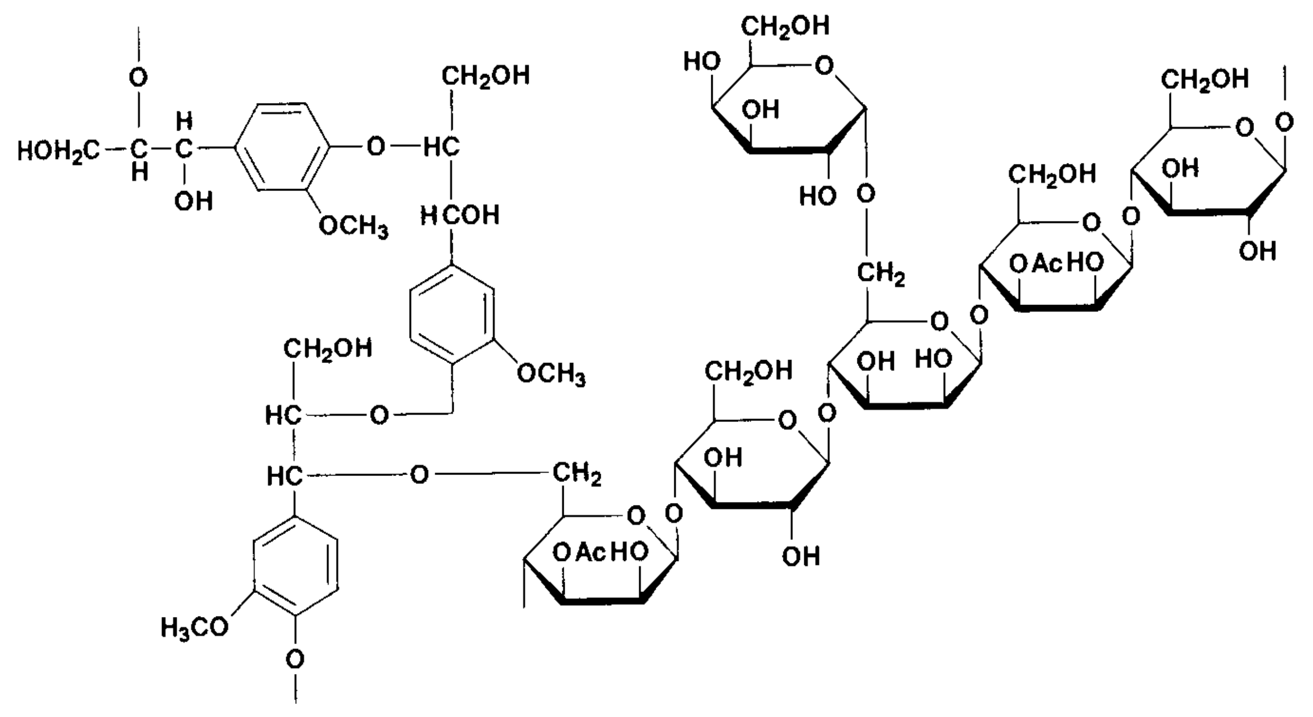


- Used to support the plant.
- Made of fiber called cellulose.
- Connected to cell membrane

Cell wall chemistry, structure

Hemicellulose:
Cell wall component in which 1,4 –linked pyranosyl units with O4 in equatorial orientation.

Conformational homology between cellulose and hemicellulose – strong non-covalent H-binding



Koshijima & Watanabe, 2003

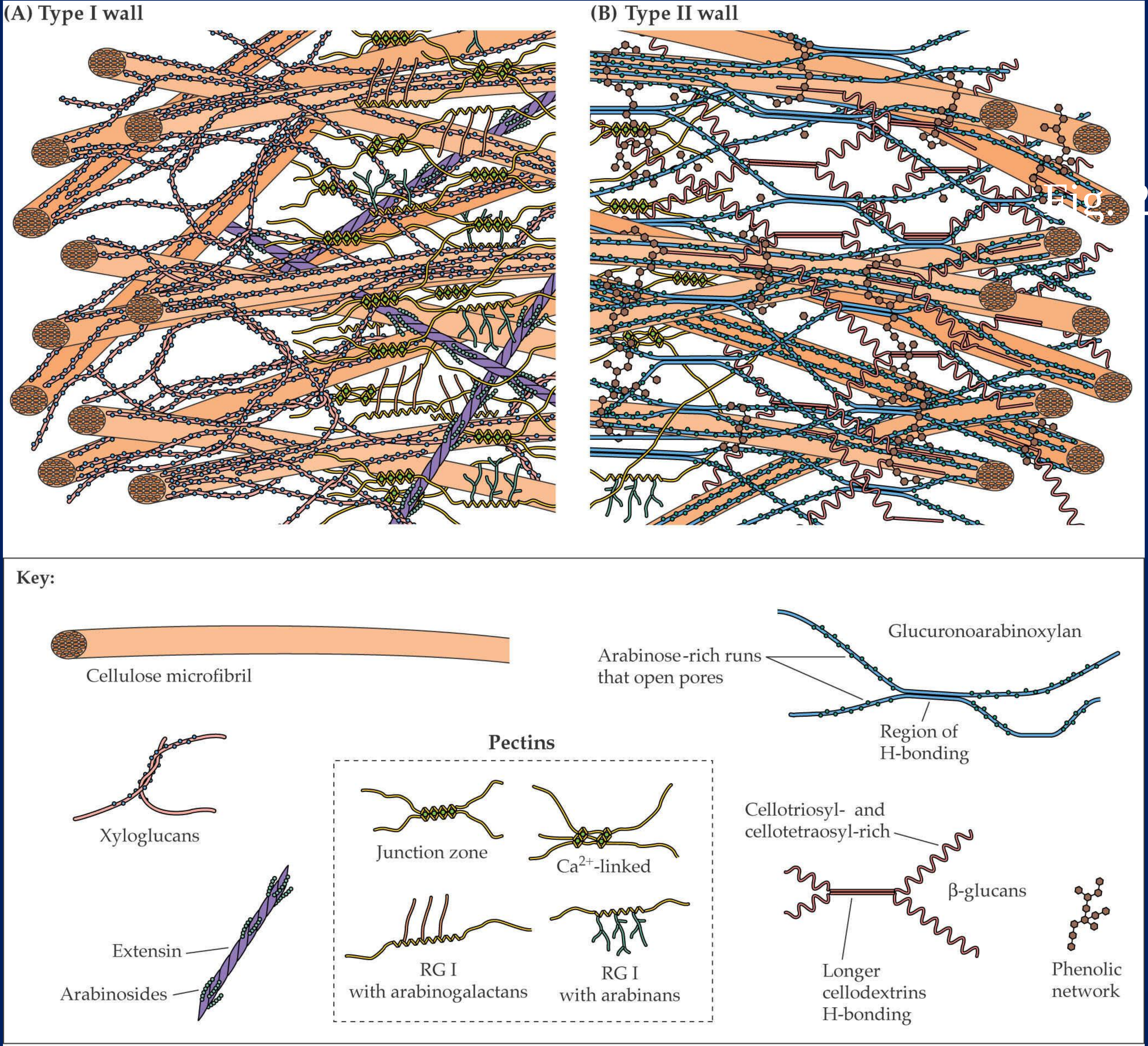

(A) Type I wall
(B) Type II wall
Key:
Cellulose microfibril
Glucuronoarabinoxylan
Arabinose-rich runs that open pores
Region of H-bonding
Xyloglucans
Pectins
Junction zone
Ca2+-linked
RG I with arabinogalactans
RG I with arabinans
Extensin
Arabinosides
Cellotriosyl- and cellotetraosyl-rich
β-glucans
Longer cellodextrins H-bonding
Phenolic network

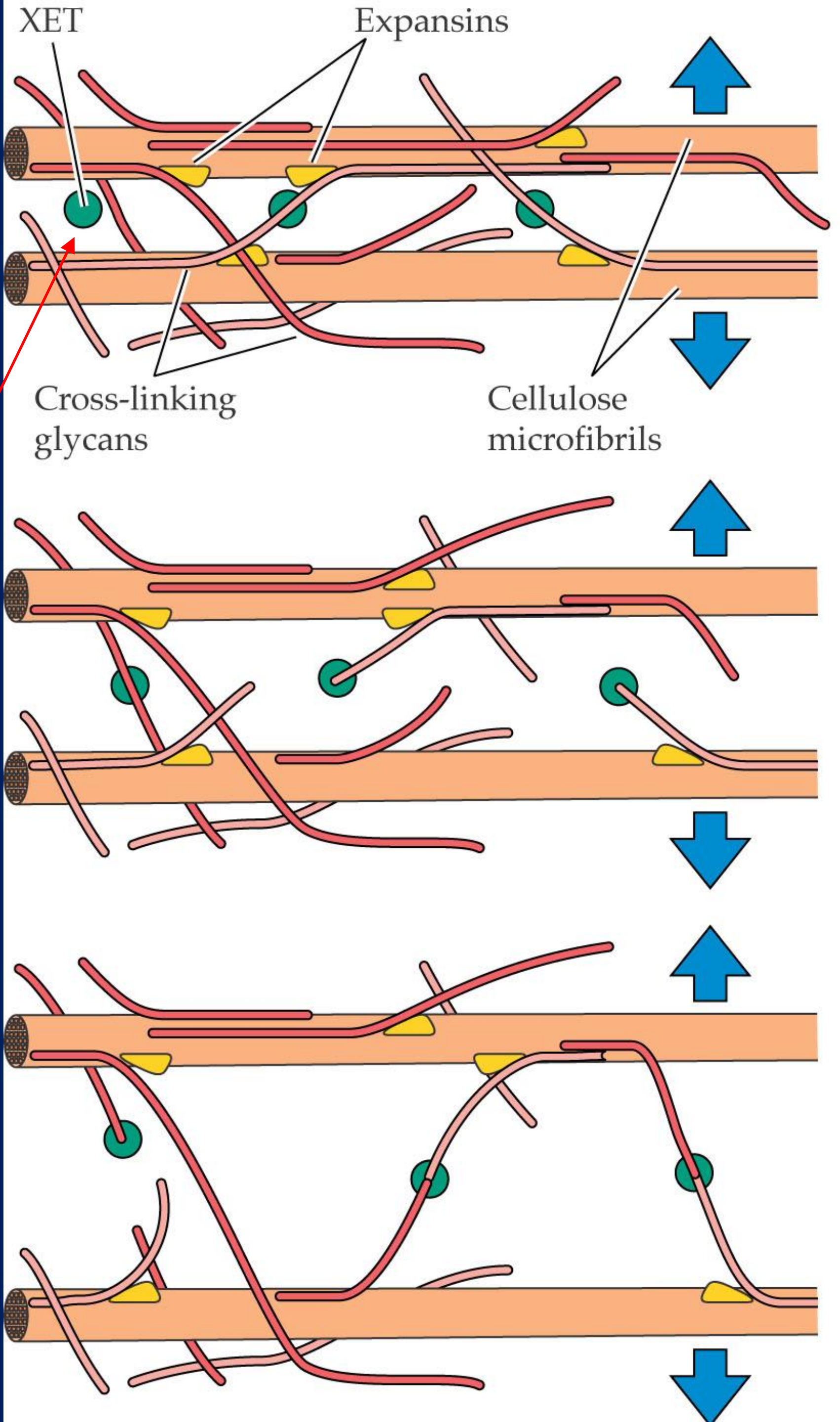
Fig. 2.23

Type I wall has about equal amounts of cellulose and xyloglucans

Xyloglucans span the distance between microfibrils.
This is embedded in a pectin matrix which controls porosity

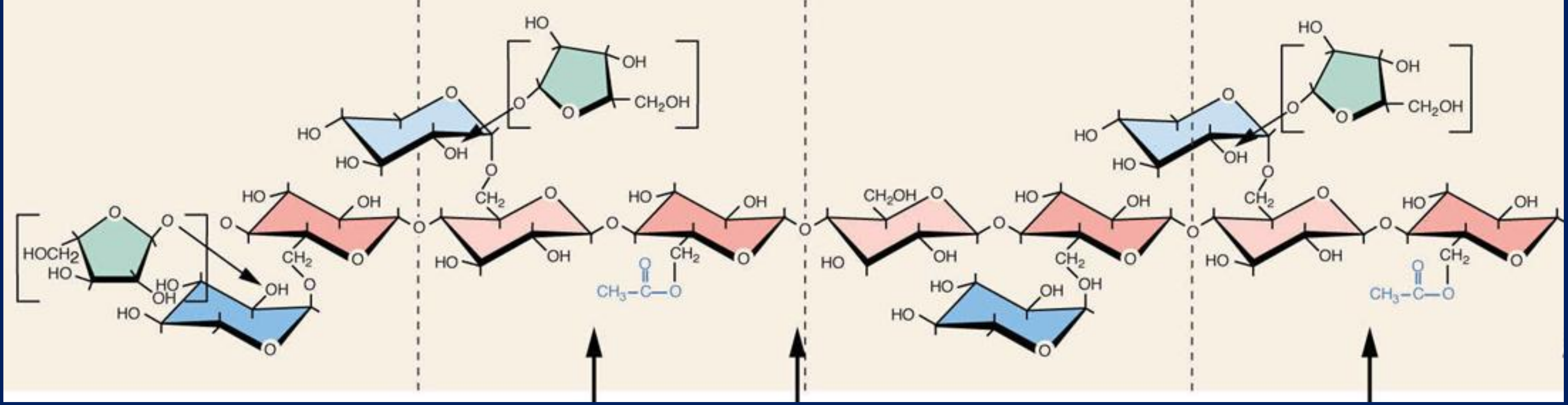
Type II wall has cellulose and glucuronoarabinoxylans

Some Xyloglucans are still present
Less pectin
Also fairly low in structural proteins but do have phenylpropanoids

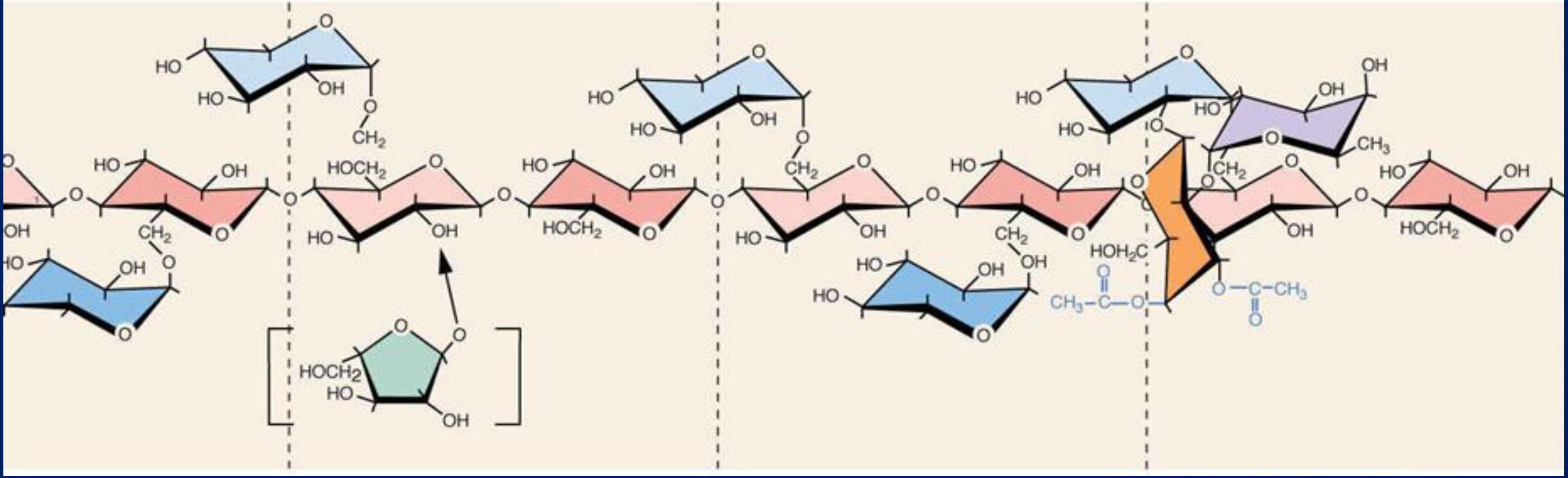


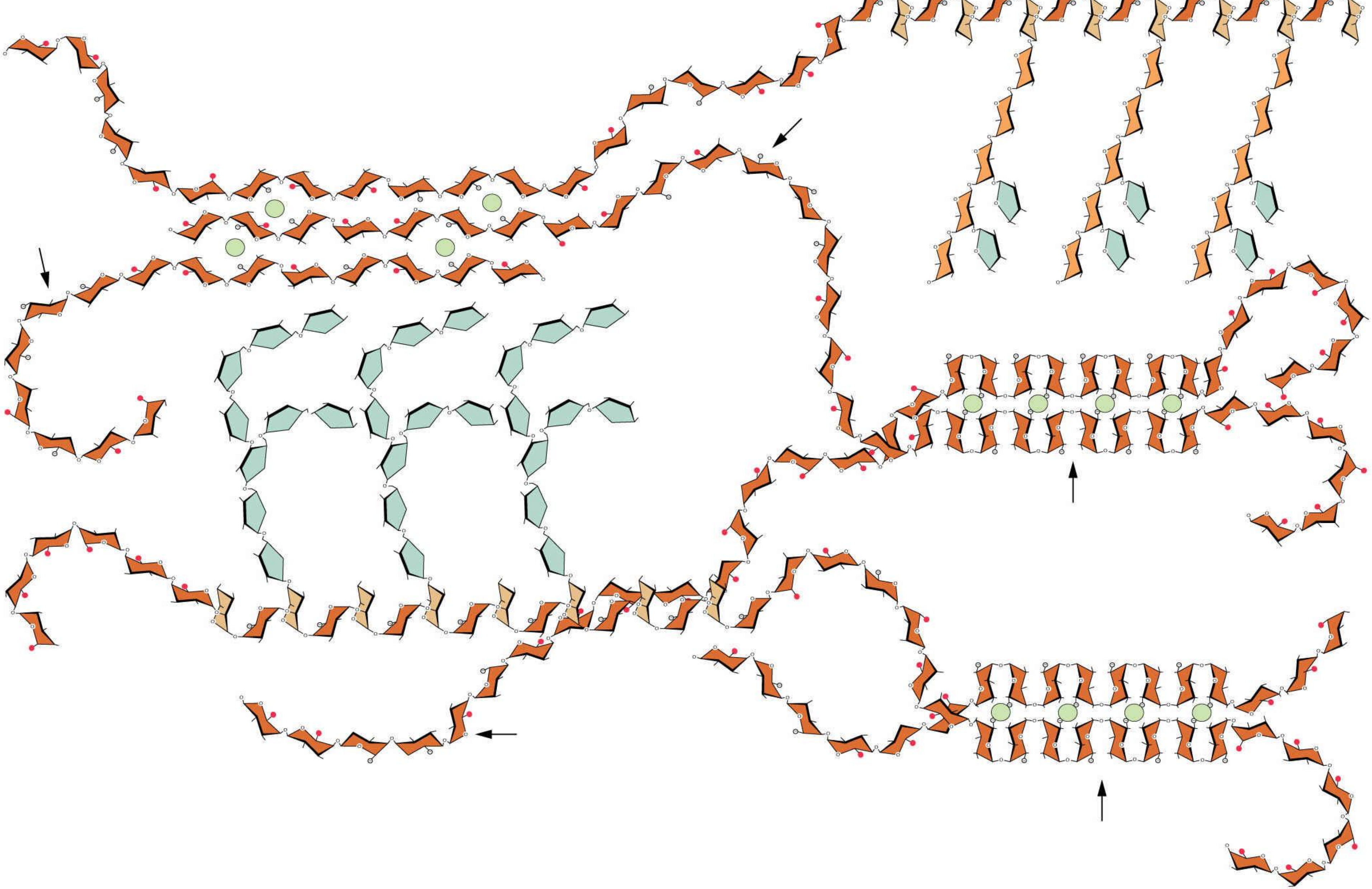
Xyloglucan Endotrans-glycosidase

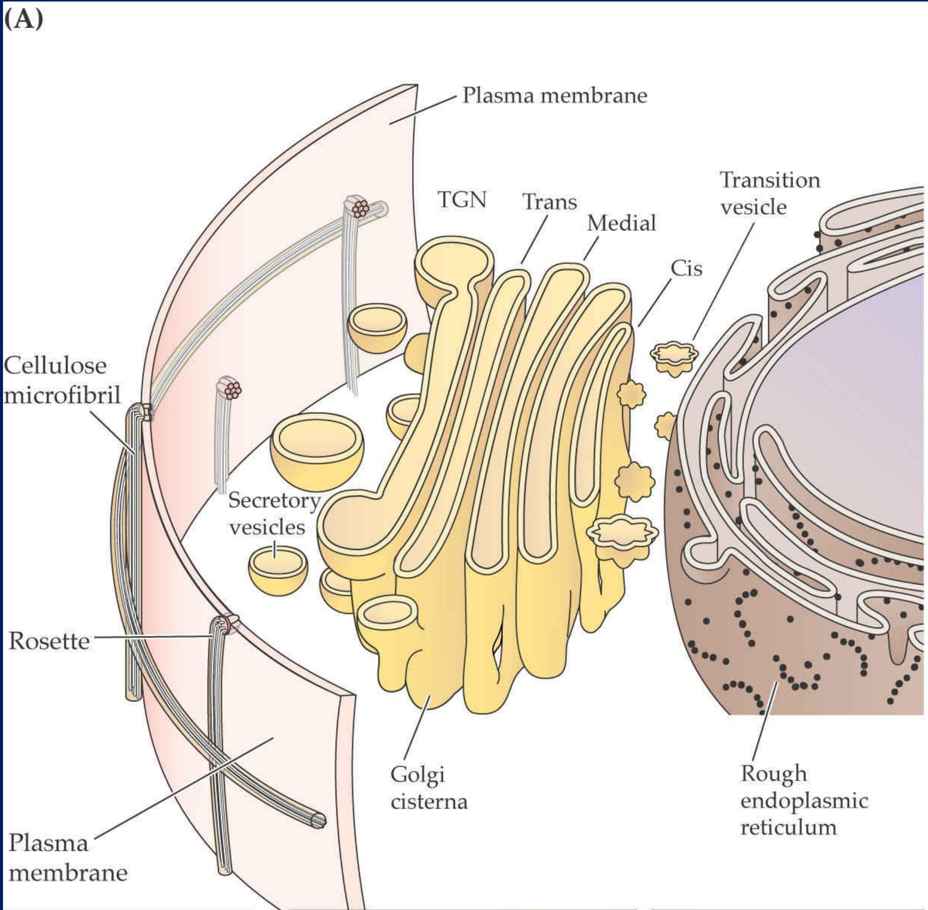
Solanaceous (arabino)xyloglucans



(Fucogalacto)Xyloglucans





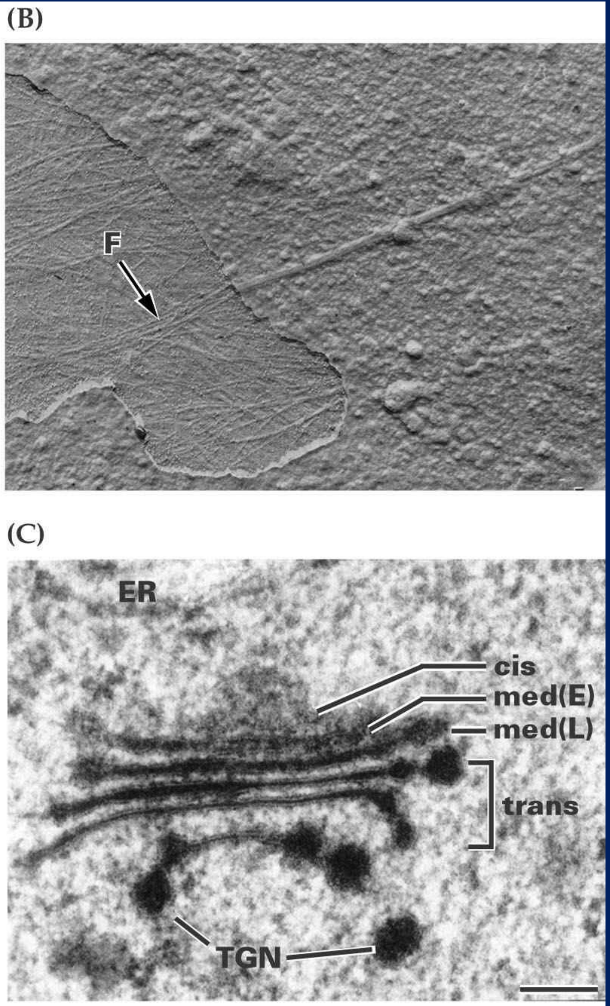


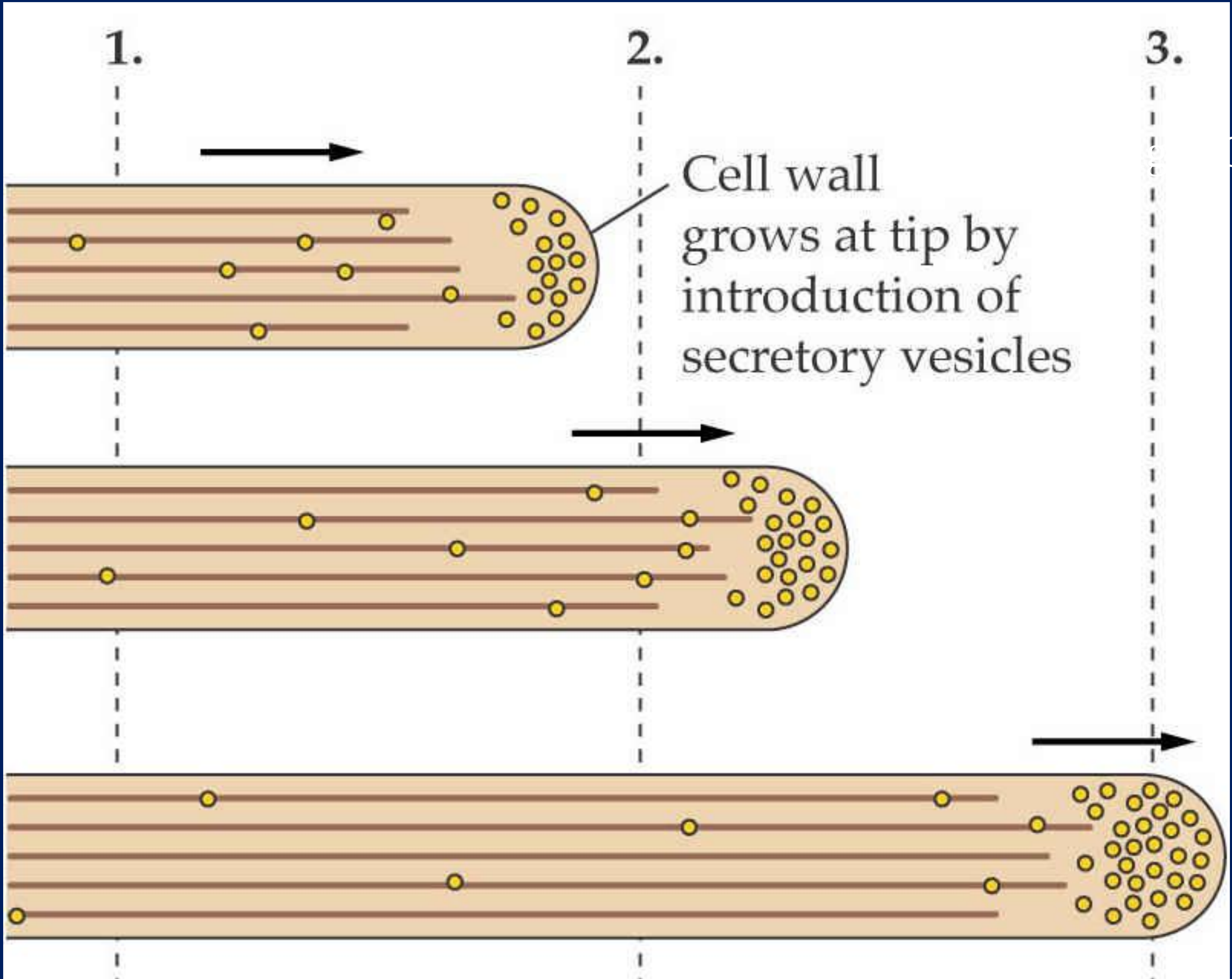
Site of synthesis for:
- Cellulose
- Callose

Site of synthesis for:
- Pectins
  - HGA
  - RG I
  - RG II
- Cross-linking glycans
  - Xyloglucan
  - Glucuronoarabinoxylan
  - β-Glucan
  - Galactomannan

Site of glycosylation of:
- HRGPs
- AGPs
- Modified glycoproteins

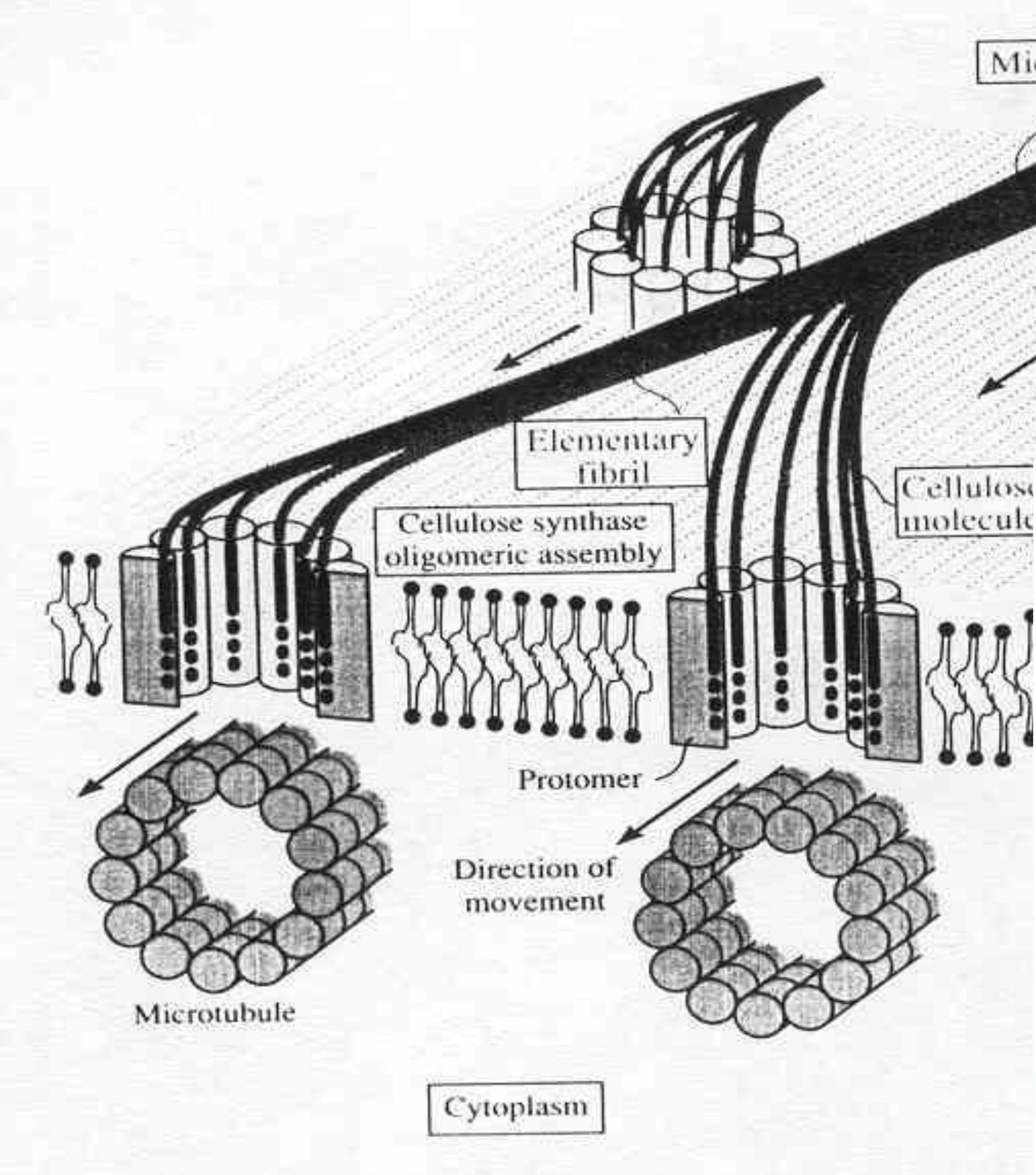
Site of synthesis for:
- Cell wall proteins
  - HRGPs
  - PRPs
  - GRPs
  - AGPs
- Enzymes
  - Hydrolases
  - Esterases
  - Peroxidases
  - Polysaccharide synthase

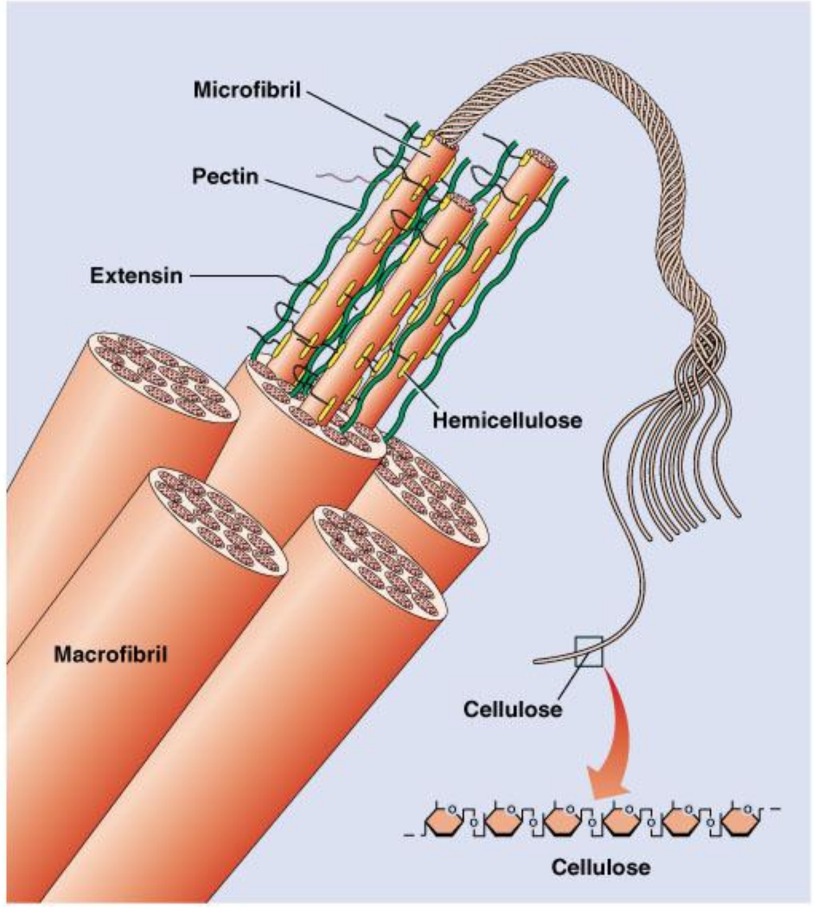




Cell wall grows at tip by introduction of secretory vesicles

g 34





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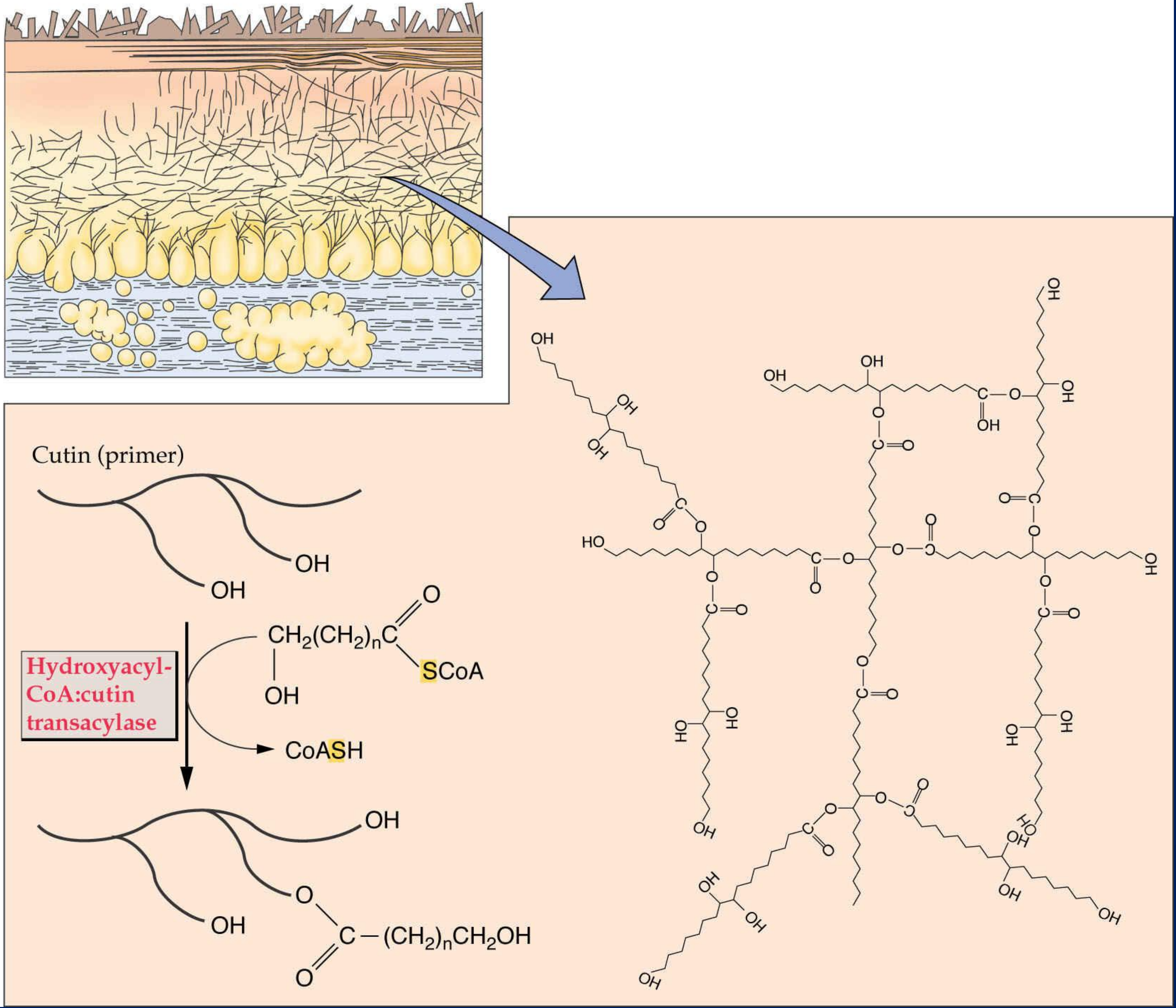
Secondary cell walls

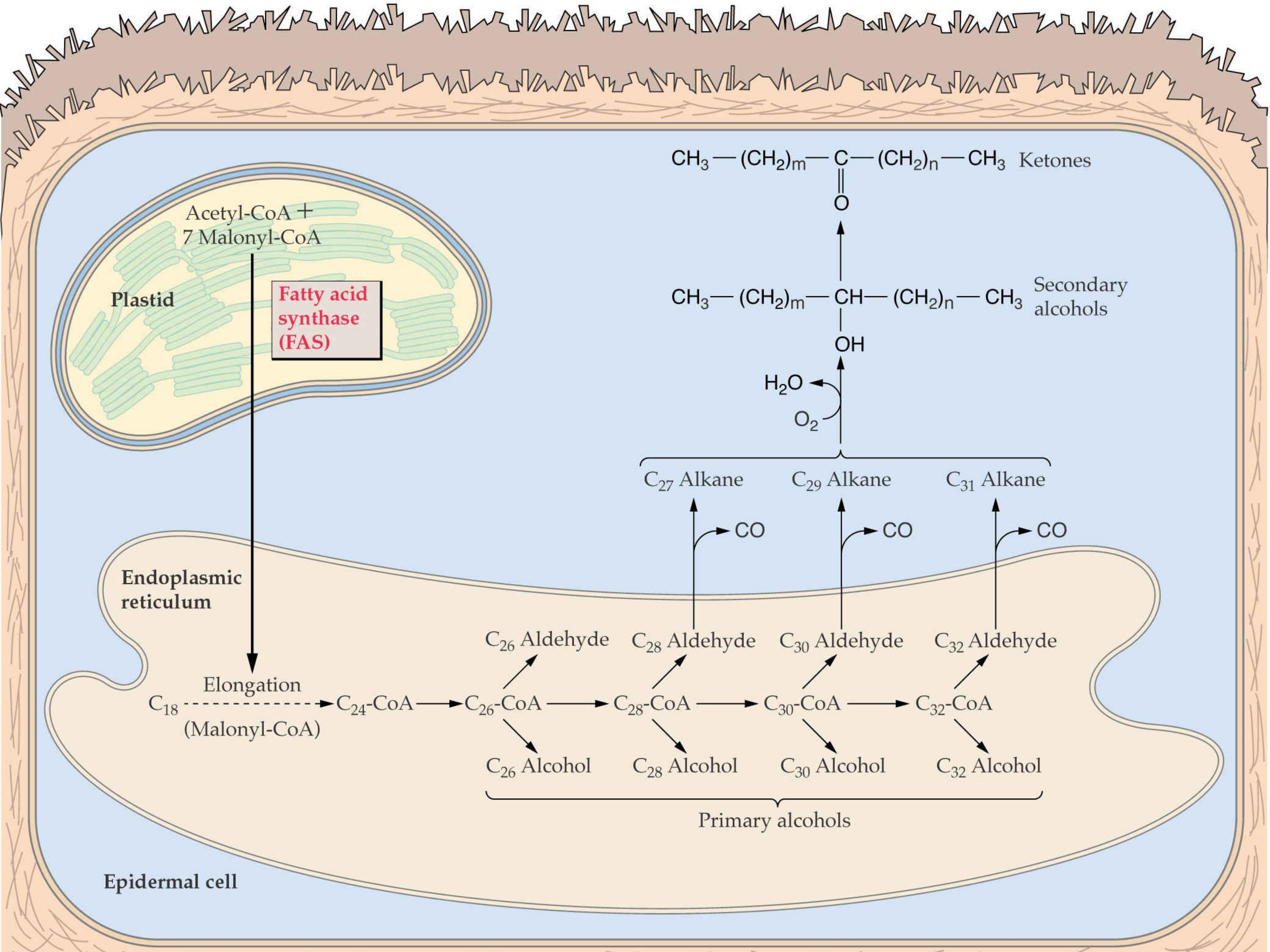
Cutin – polymeric network of oxygenated
C16 and C18 fatty acids

Inelastic and hydrophobic but NOT a significant
barrier to water loss – pathogen defense - yes

Suberin – similar but longer fatty acids, less oxygenated
And linked to phenolics – more hydrophobic than cutin

Aerial surfaces covered with waxes – extremely long
Chain fatty acids – prevents water loss

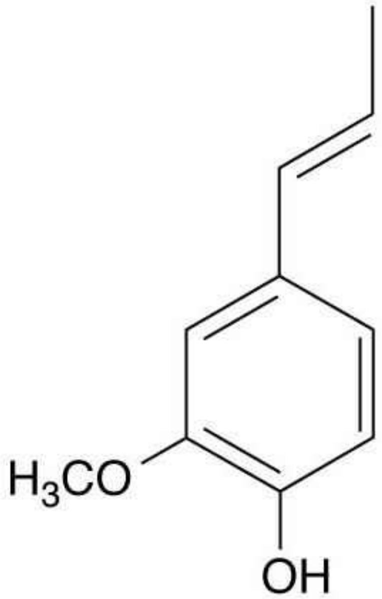

Cutin (primer)
OH
OH
Hydroxyacyl-CoA:cutin transacylase
$CH_2(CH_2)_nC(=O)SCoA$
OH
CoASH
OH
OH
O
$C-(CH_2)_nCH_2OH$
O
HO
OH


Acetyl-CoA +
7 Malonyl-CoA
Plastid
Fatty acid synthase (FAS)
$CH_3—(CH_2)_m—C(=O)—(CH_2)_n—CH_3$ Ketones
$CH_3—(CH_2)_m—CH(OH)—(CH_2)_n—CH_3$ Secondary alcohols
H_2O
O_2
C_{27} Alkane
C_{29} Alkane
C_{31} Alkane
CO
CO
CO
Endoplasmic reticulum
C_{26} Aldehyde
C_{28} Aldehyde
C_{30} Aldehyde
C_{32} Aldehyde
Elongation
C_{18}
(Malonyl-CoA)
C_{24}-CoA
C_{26}-CoA
C_{28}-CoA
C_{30}-CoA
C_{32}-CoA
C_{26} Alcohol
C_{28} Alcohol
C_{30} Alcohol
C_{32} Alcohol
Primary alcohols
Epidermal cell

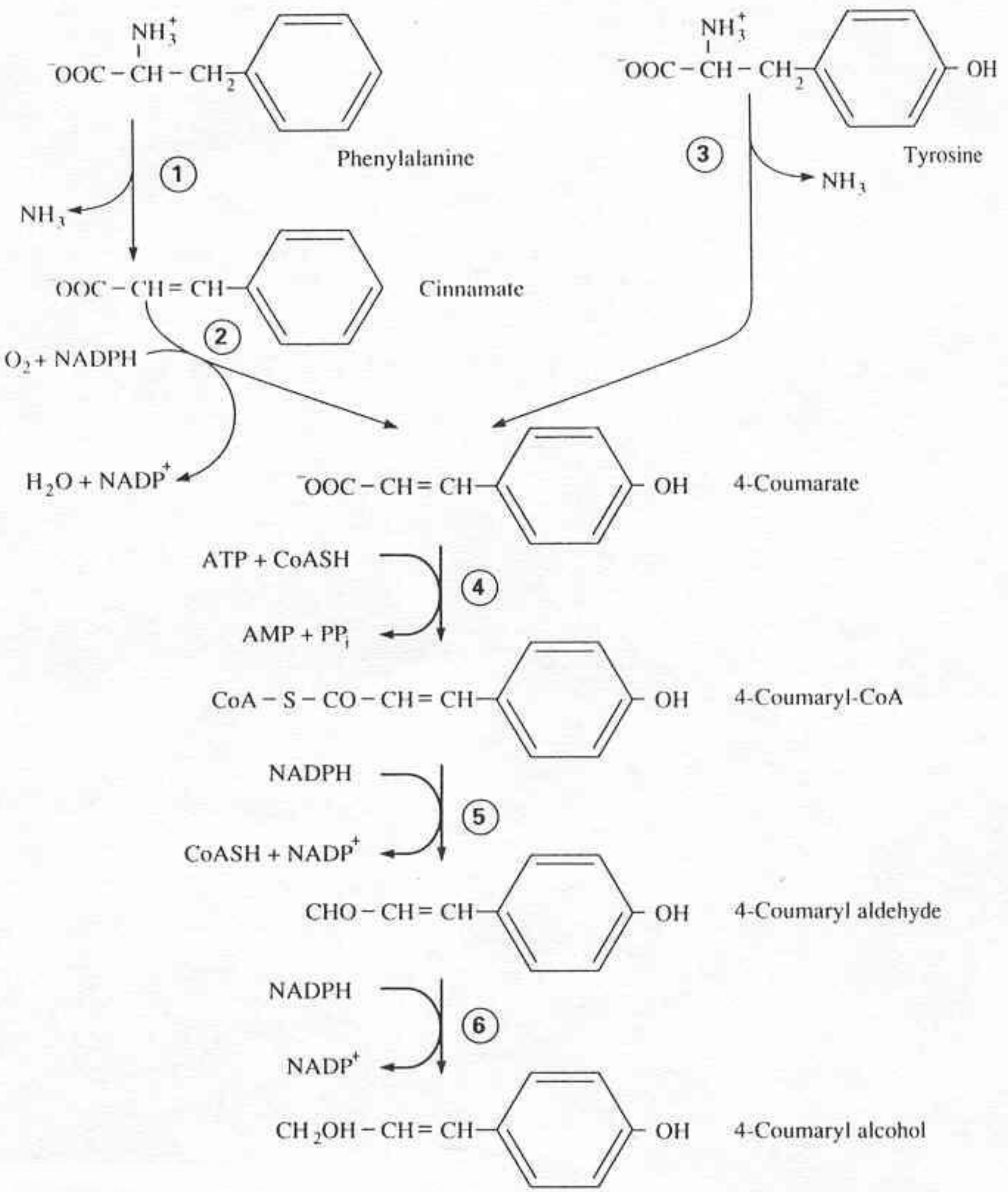
Lignin - very resistant to solubilization
40% HCl used

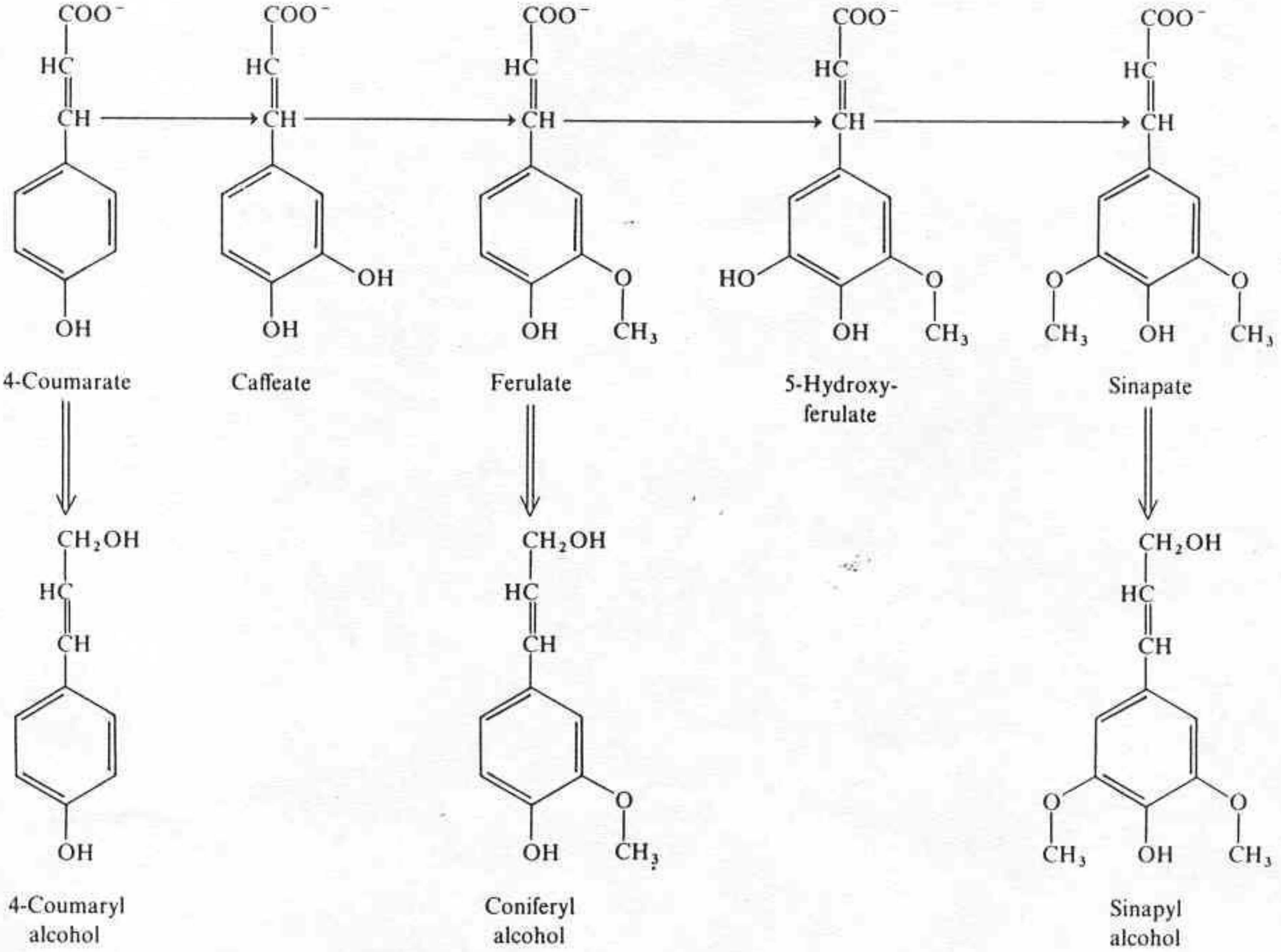
Made of linked phenylpropane units

An example of a "lignan" component

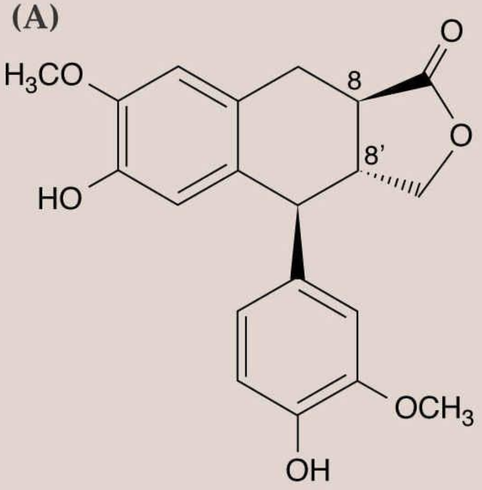


Isoeugenol


Phenylalanine
1
NH3
Cinnamate
2
O2 + NADPH
H2O + NADP+
Tyrosine
3
NH3
4-Coumarate
ATP + CoASH
4
AMP + PPi
4-Coumaryl-CoA
NADPH
5
CoASH + NADP+
4-Coumaryl aldehyde
NADPH
6
NADP+
4-Coumaryl alcohol

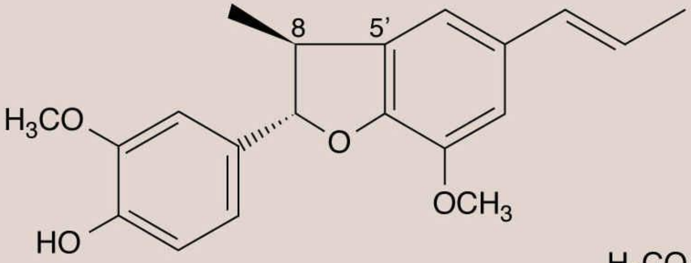

4-Coumarate
Caffeate
Ferulate
5-Hydroxy-ferulate
Sinapate
4-Coumaryl alcohol
Coniferyl alcohol
Sinapyl alcohol

(A)



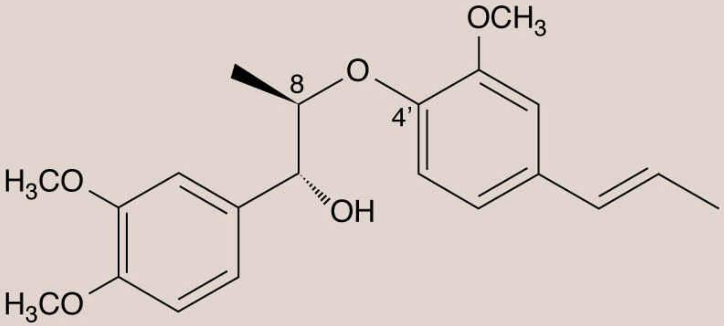
α-Conidendrin (8–8′)

(B)

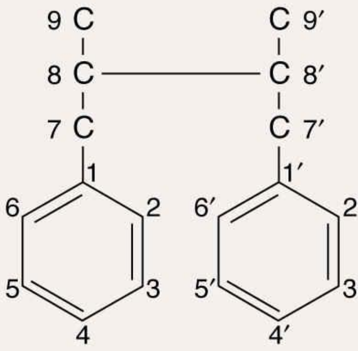


Licarin A (8–5′)

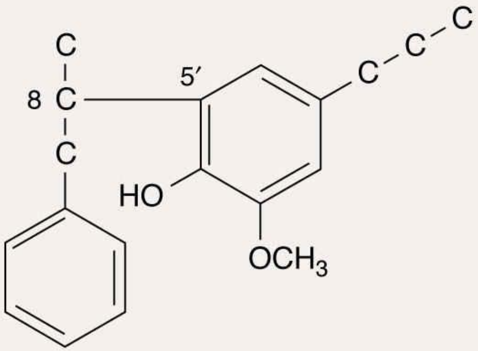
(C)



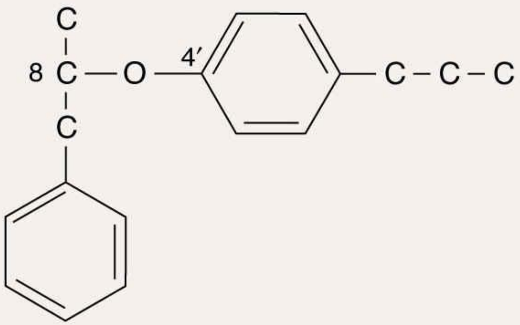
Virolin (8–*O*–4′)



(8–8′)

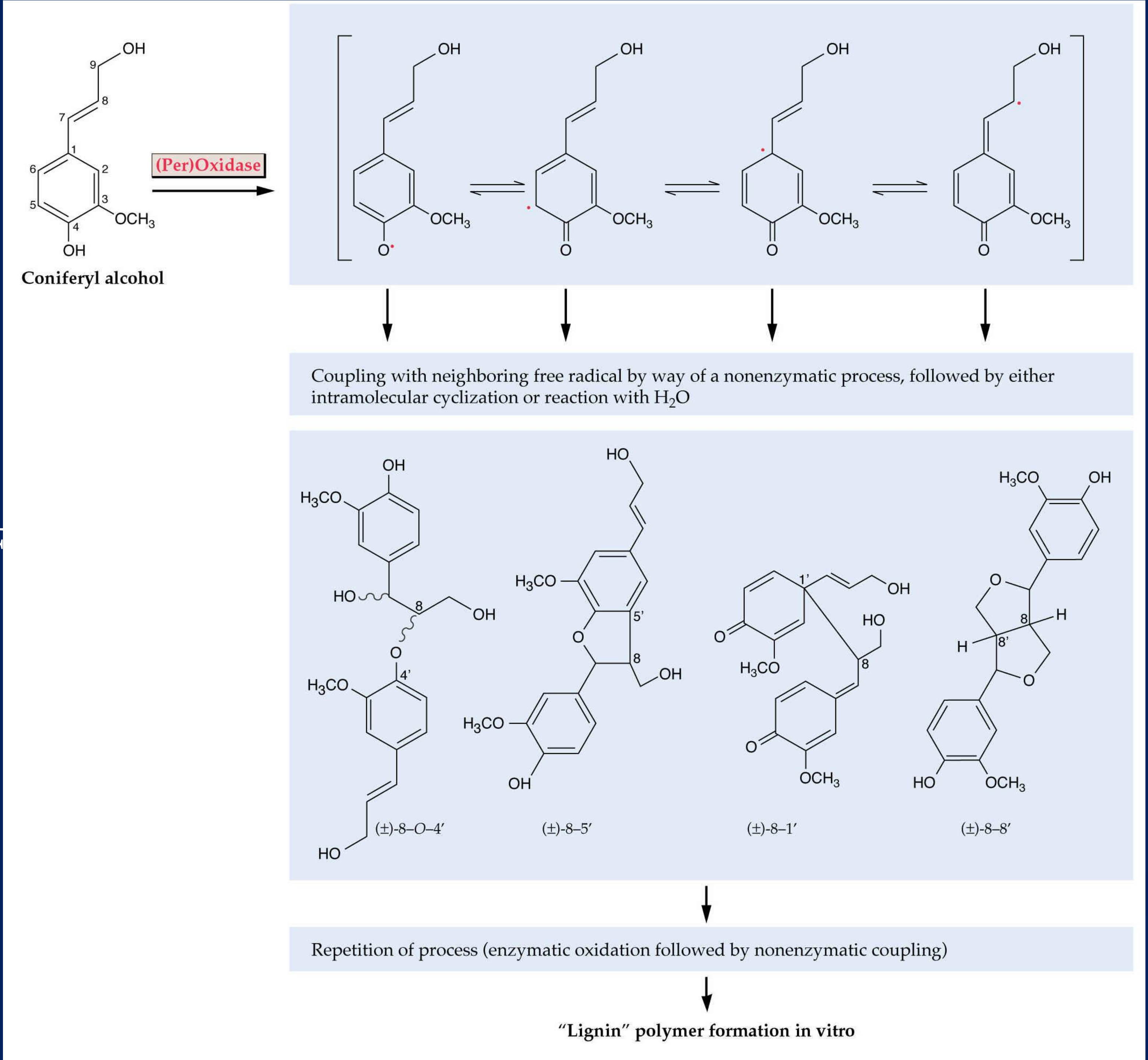


(8–5′)



(8–*O*–4′)

F

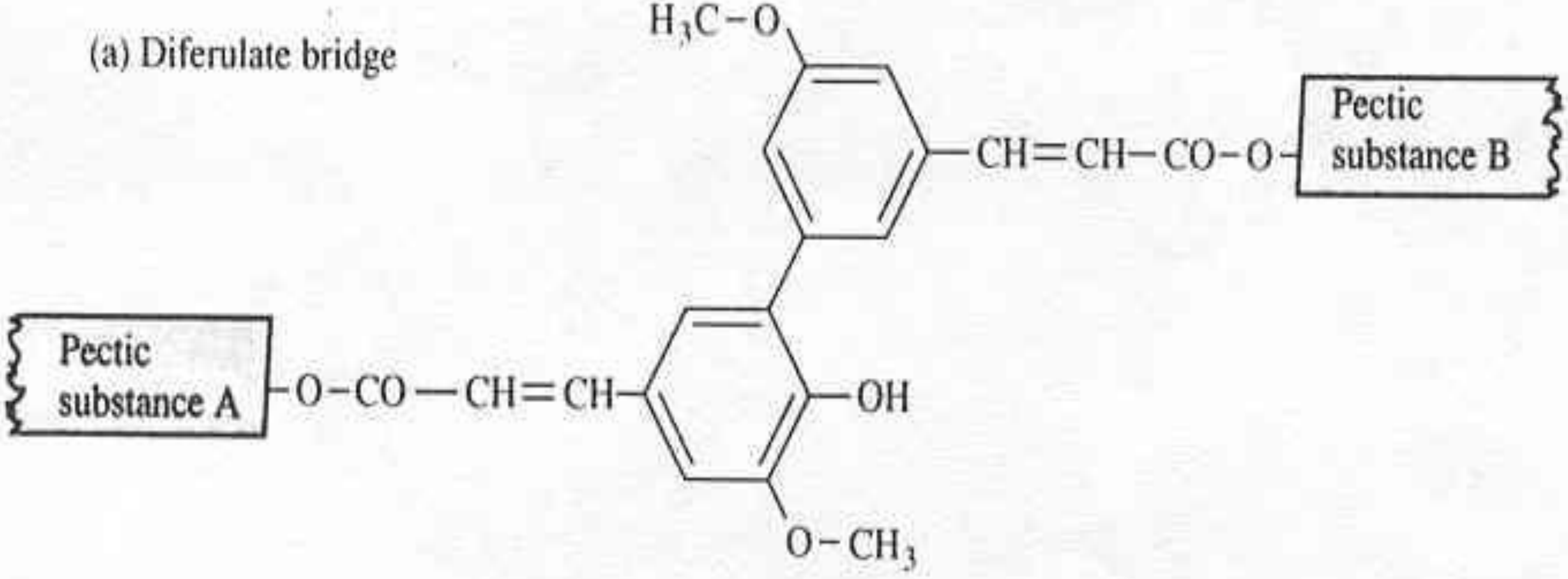


Coupling with neighboring free radical by way of a nonenzymatic process, followed by either intramolecular cyclization or reaction with H_2O

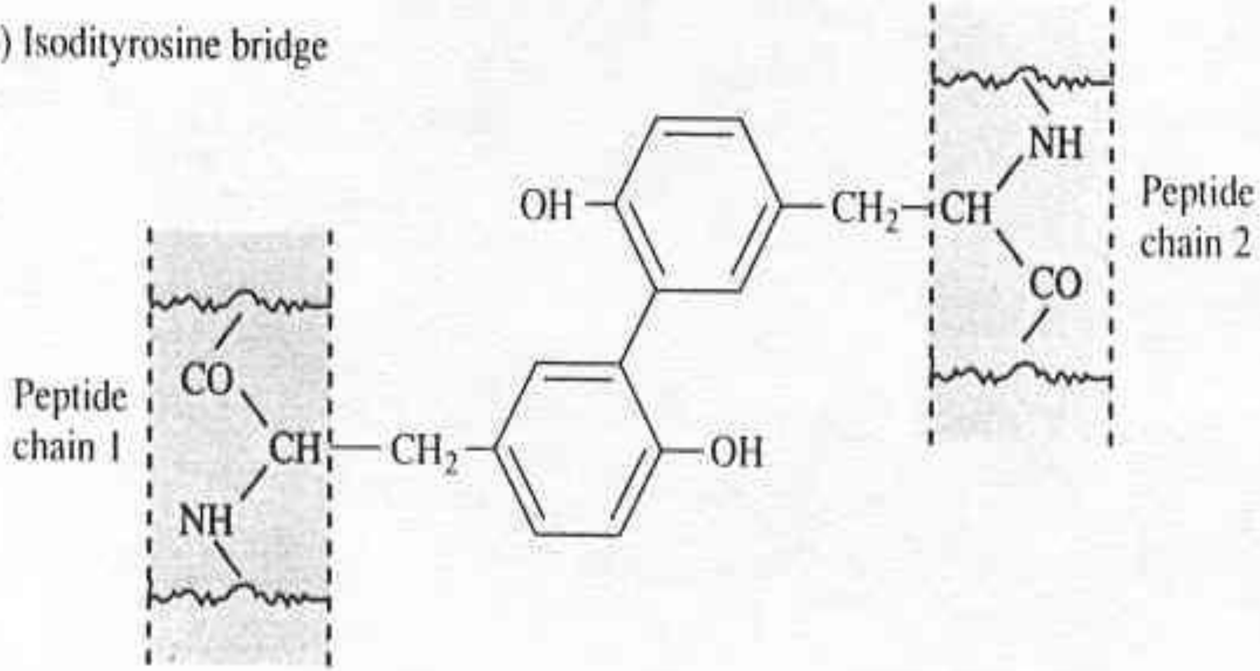
Repetition of process (enzymatic oxidation followed by nonenzymatic coupling)

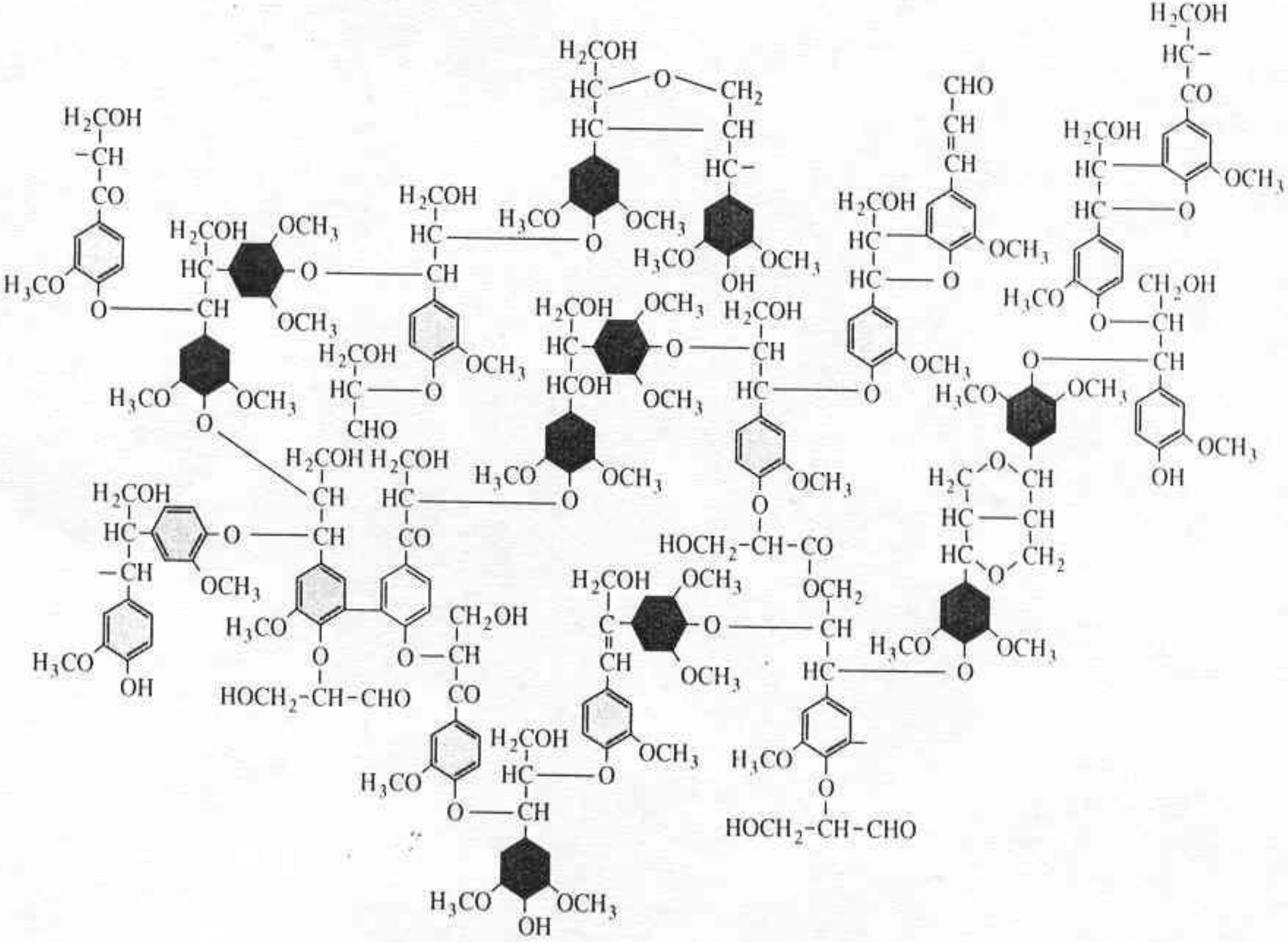
“Lignin” polymer formation in vitro

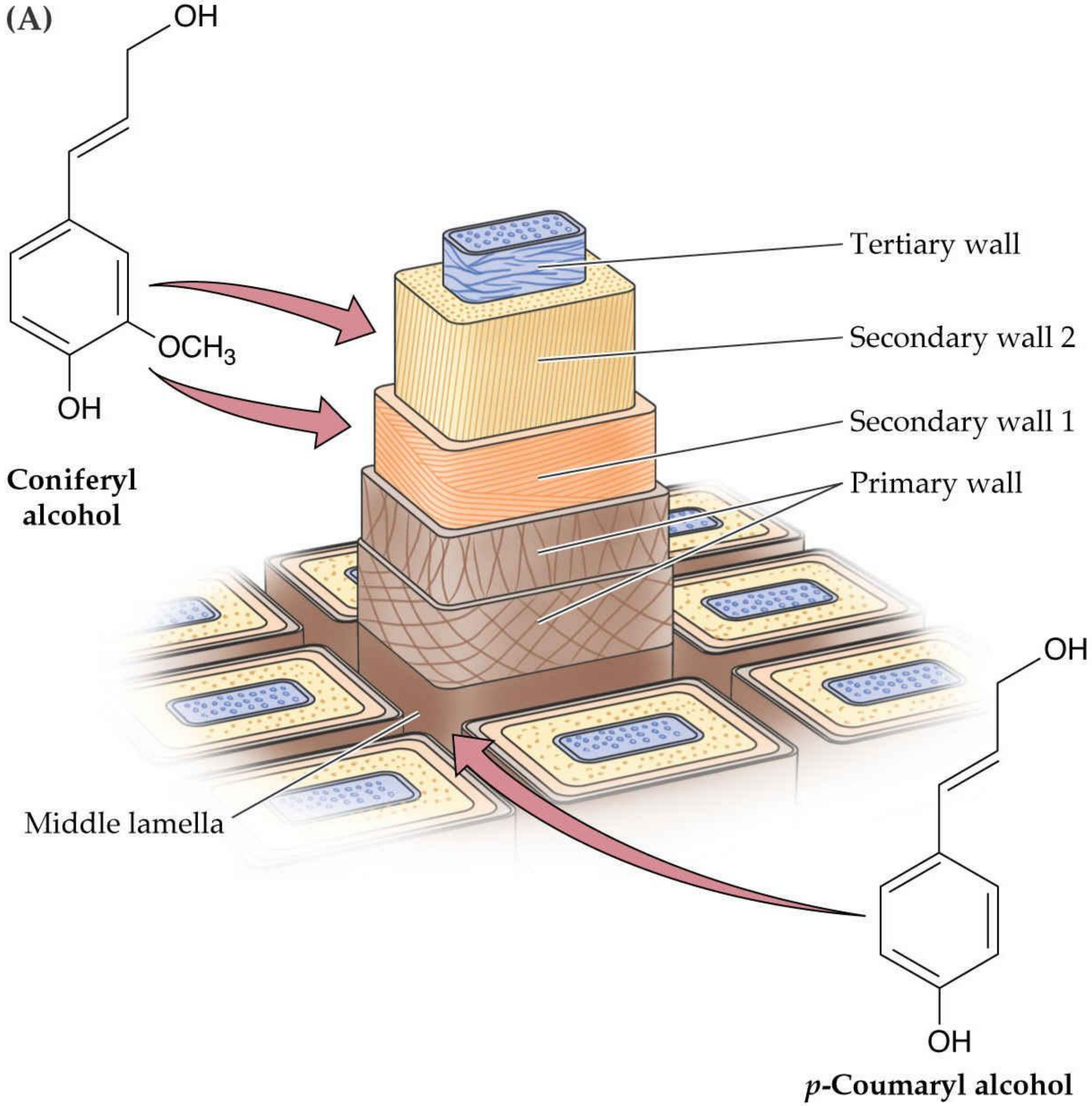
(a) Diferulate bridge



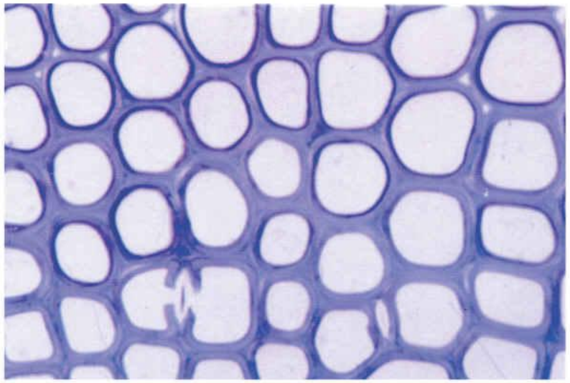
(b) Isodityrosine bridge



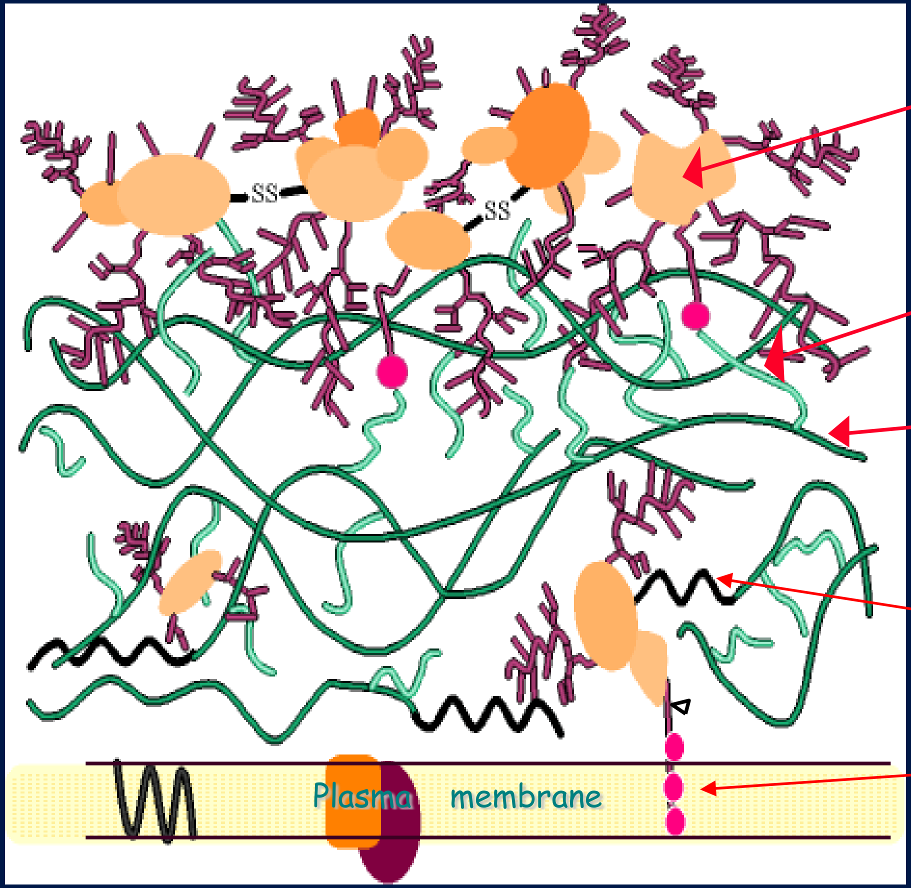




(B) Normal secondary xylem



Клеточная стенка у грибов



Mannoproteins (40%)

Outer cell wall

β (1,6) glucans (8%)

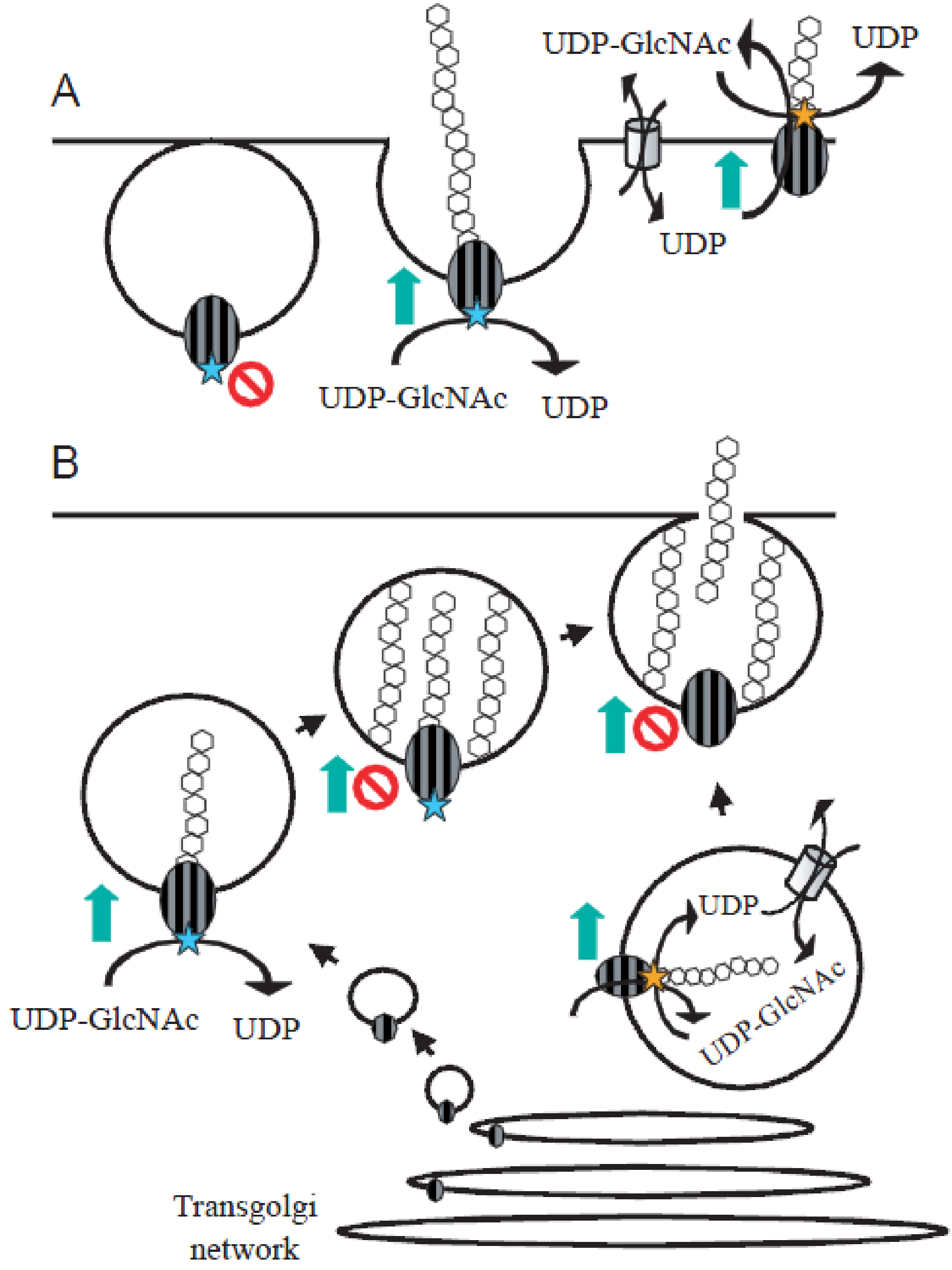
β (1,3) glucans (50%)

Inner cell wall

Chitin (2%)

Glycophospholipid-anchored surface protein

Синтез хитина у насекомых



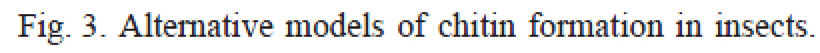


Fig. 3. Alternative models of chitin formation in insects.

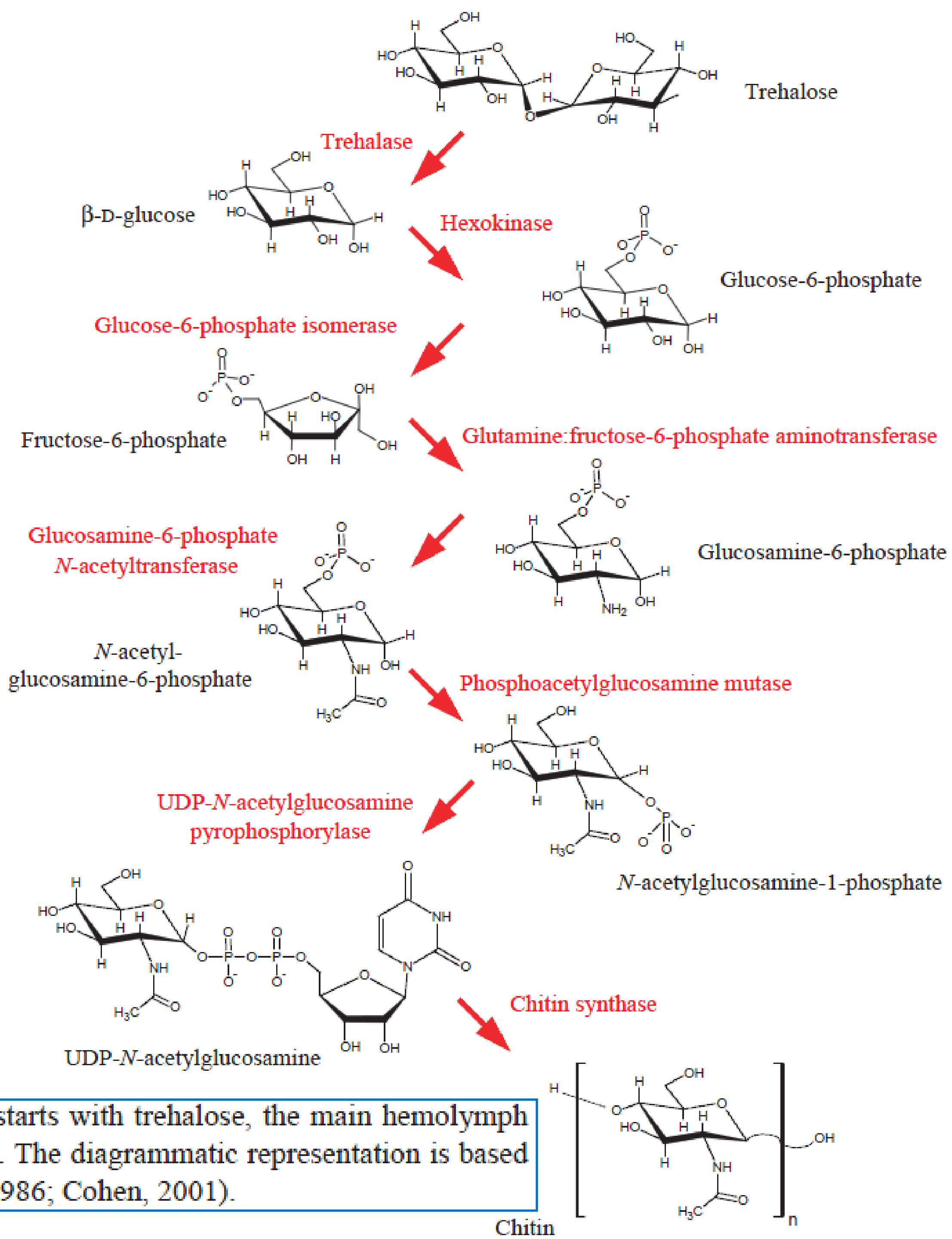

Trehalose
Trehalase
β-D-glucose
Hexokinase
Glucose-6-phosphate
Glucose-6-phosphate isomerase
Fructose-6-phosphate
Glutamine:fructose-6-phosphate aminotransferase
Glucosamine-6-phosphate
Glucosamine-6-phosphate N-acetyltransferase
N-acetyl-glucosamine-6-phosphate
Phosphoacetylglucosamine mutase
N-acetylglucosamine-1-phosphate
UDP-N-acetylglucosamine pyrophosphorylase
UDP-N-acetylglucosamine
Chitin synthase
Chitin

Fig. 1. Biosynthesis of chitin in insects. The pathway starts with trehalose, the main hemolymph sugar in most insects, and ends with the chitin polymer. The diagrammatic representation is based on previously published pathways (Kramer and Koga, 1986; Cohen, 2001).